UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
64317/99

Total Pages in this Submission

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF

and invented by:

Shoichi Kuroha

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

❑ **Continuation**   ❑ **Divisional**   ❑ **Continuation-in-part (CIP)**   of prior application No.: _____

Which is a:

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Enclosed are:

Application Elements

1. ☒   Filing fee as calculated and transmitted as described below

2. ☒   Specification having _____32_____ pages and including the following:

   a. ☒   Descriptive Title of the Invention

   b. ❑   Cross References to Related Applications *(if applicable)*

   c. ❑   Statement Regarding Federally-sponsored Research/Development *(if applicable)*

   d. ❑   Reference to Microfiche Appendix *(if applicable)*

   e. ☒   Background of the Invention

   f. ☒   Brief Summary of the Invention

   g. ☒   Brief Description of the Drawings *(if drawings filed)*

   h. ☒   Detailed Description

   i. ☒   Claim(s) as Classified Below

   j. ☒   Abstract of the Disclosure

P01ULRG/REV04

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*

   a. ☒ Formal   Number of Sheets   **21 (Figs. 1-21)**

   b. ❑ Informal   Number of Sheets

4. ☒ Oath or Declaration

   a. ☒ Newly executed *(original or copy)*   ❑ Unexecuted

   b. ❑ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*

   c. ☒ With Power of Attorney   ❑ Without Power of Attorney

   d. ❑ *DELETION OF INVENTOR(S)*
       Signed statement attached deleting inventor(s) named in the prior application,
       see 37 C.F.R. 1.63(d)(2) and 1.33(b).

5. ❑ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ❑ Computer Program in Microfiche *(Appendix)*

7. ❑ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*

   a. ❑ Paper Copy

   b. ❑ Computer Readable Copy *(identical to computer copy)*

   c. ❑ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & document(s))*

9. ❑ 37 CFR 3.73(B) Statement *(when there is an assignee)*

10. ❑ English Translation Document *(if applicable)*

11. ❑ Information Disclosure Statement/PTO-1449   ❑ Copies of IDS Citations

12. ❑ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ❑ Certificate of Mailing

   ❑ First Class   ❑ Express Mail *(Specify Label No.):*

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Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Additional Enclosures *(please identify below):*

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	17	- 20 =	0	x $18.00	$0.00
Indep. Claims	3	- 3 =	0	x $78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$690.00
OTHER FEE *(specify purpose)*			Assignment Recordation		$40.00
				TOTAL FILING FEE	$730.00

☒ A check in the amount of $730.00   to cover the filing fee is enclosed.

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   ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance,
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Signature

Dated: **March 10, 2000**

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APPLICATION
FOR
UNITED STATES
LETTERS PATENT

APPLICANT:	**Shoichi Kuroha**
FOR:	**LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF**
DOCKET NO.:	**64317/99**

LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF
BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a liquid crystal

5 display (LCD) and its manufacturing method.

Description of the Related Art

The TN (twisted nematic) mode is one of the current

modes used for LCD devices. In this mode, an electric field

vertical to the surface of the substrate is used to orient

10 the liquid crystal molecule director (the molecular major

axis). By doing this, the optical transmittance is

controlled so that an image can be displayed on the LCD panel.

This is a common type (hereafter called a vertical electric

field driver-type) of LCD device.

15 Since, with the vertical electric field driver-type LCD,

the director is oriented to be vertical to the surface of the

substrate when the electric field is applied, the refractive

index changes depending on the viewing angle. Accordingly,

the vertical electric field driver-type LCD is not suitable

20 when a wide viewing angle is needed.

There are also LCD devices where the liquid crystal

director is oriented parallel to the surface of the substrate.

These are devices where the electric field functions in a

direction parallel to the surface of the substrate so that

25 the director can rotate in a plane parallel to the surface of

the substrate. Through this, the optical transmittance is

controlled, and an image is displayed. This type (hereafter

called a lateral electric field driver-type) of LCD device has only just been developed in recent years. With the lateral electric field driver-type LCD, because the change in refractive index due to the viewing angle is remarkably small,

5   a high quality display can be obtained.

An example of this type of lateral electric field driver-type LCD is shown in Figs. 1 to 3. Fig. 1 is a plan view of a vertical electric field driver-type LCD, Fig. 2 is a cross-sectional view of the LCD in Fig. 1 taken along the

10 line JJ', and Fig. 3 is a cross-sectional view of the LCD in Fig. 1 taken along the line KK'. The pixel shown in these diagrams is formed of the following elements: a data line 1, a scanning line 2, a thin film transistor (TFT) 3, a common electrode 4 and a pixel electrode 5. The scanning line 2 is

15 connected to an external drive circuit (not shown in the figures). The TFT 3 is a switching device. The scanning line 2 and the common electrode 4 are both structured on a substrate 10 where TFTs are fabricated (hereafter, called TFT substrate 10). The pixel electrode 5 and the data line 1 are

20 structured on the scanning line 2 and the common electrode 4 via an interlayer insulation film 7. The pixel electrode 5 and the common electrode 4 are alternately positioned. These electrodes are covered with a protection/insulation film 8. On the protection/insulation film 8, an alignment layer 15 is

25 laid and subjected to a rubbing treatment.

A black matrix 9 to shield light is structured in a matrix format on the underside of the opposite facing glass

substrate 11. The primary and secondary colored layers 12
and 13, which are necessary for color display, are prepared
on the black matrix 9. Each of the colored layers 12 and 13
are assigned to each pixel. Here, the above two colors

5 represent two of the three primary colors: red, green, and
blue. But, the one remaining colored layer is not shown in
the figures.

On top of the primary and secondary colored layers 12,
13, an over-coating film 14 necessary to make the opposite

10 facing substrate 11 flat is prepared. An alignment layer 16,
which will be necessary to orient the liquid crystal 18, is
laid on the over-coating film 14 and then subjected to a
rubbing treatment. The rubbing treatment is performed in the
direction opposite to that performed on top surface of the

15 TFT substrate 10.

Next, liquid crystal 18 and spacers 17 are poured into
the gap between the TFT substrate 10 and the opposite-facing
substrate 11. The spacers 17 are randomly distributed
throughout the area between them. The minimum distance

20 between the two substrates determines the diameter of the
spacers 17.

A polarizer film (not shown in the figures) is applied
to the outer surface of the TFT substrate 10 where the
electrode patterns have not been formed. This polarizer

25 film is applied in a manner such that the transmission axis
runs in the direction perpendicular to the direction of the
rubbing. A polarizer film (also not shown in the figures) is

applied to the outer surface of the opposite facing glass substrate 11 where there are no layered patterns. The transmission axis of the polarizer film on the opposite facing glass substrate 11 is perpendicular to the direction

5　of the transmission axis of the polarizer film on the TFT substrate 10.

The LCD panel with the above structure is set up on a backlight and attached to a drive circuit.

In the above mentioned conventional LCD device, the

10　liquid crystal poured into the narrow gap between the TFT substrate and the opposite facing substrate is normally oriented parallel to the direction that the rubbing treatment was performed on the alignment layers 15 and 16. As shown in Fig. 4, the liquid crystal molecules 20 surrounding each

15　spacer 17 are oriented parallel to the surface of the spacer 17. In this case, when the screen is in normally black mode (i.e. the mode where no light can pass through when no voltage is applied), light permeates through the area where the liquid crystal molecules are lined up askew to the

20　polarizer film absorption axis (for example, the liquid crystal molecules in region 21). Due to this, a leakage of light develops in the fan blade-shaped regions 21. In addition, the weak aligning force causes the alignment of the liquid crystal surrounding the spacers 17 to fall into

25　disorder. When this happens, the amount of leakage of light around the spacers 17 increases; subsequently, as shown in Fig. 5, a doughnut-shaped region 21 of leakage of light

develops.

Furthermore, when the liquid crystal panel happens to be impacted, the spacer 17 becomes charged by the friction created from being scraped against the alignment layers on the TFT substrate and the opposite facing substrate respectively. Once this occurs, a radial electric field develops around the spacers 17. In this case, because the liquid crystal molecules 20 become aligned parallel to the electric field, fan blade-shaped regions 21 of leakage of light develop, as shown in Fig. 6.

At this point, when comparing the two cases where the spacer 17 is not charged as shown in Fig. 4 and where the spacer 17 has been charged up as shown in Fig. 6, it is apparent that the latter case gives larger radial areas of leakage of light 21.

This type of charging occurs when a certain pressure or impact, which happens to hit the LCD panel, causes spacers that are positioned in the opaque region of liquid crystal molecules (i.e., in the region of crystal molecules under the black matrix) to move and be strongly rubbed by the top surfaces of the alignment layers. This occurs easily since the gap at the opaque region (i.e., the region under the black matrix 9 and on the data line 1, the scanning line 2, the TFT 3, etc.) is narrower than the gap at the transparent regions, which widens the contact area of the spacer with either surface of the alignment layers. The wider contact area allows a conveyance of a strong force, which is caused

by the certain pressure or impact being applied to the LCD panel, onto the spacer. This force can easily push and move the spacer out into a transparent region of liquid crystal molecules. An electrically charged spacer that has entered

5   the transparent region increases the total amount of leakage of light, which in turn causes a deterioration of display quality. On the other hand, a spacer that is originally positioned within the transparent region of liquid crystal molecules is rarely charged electrically by this type of

10 movement since the gap of the transparent region is wider.

As described above, when a certain pressure or impact is applied to the LCD panel, the spacer that is positioned within an opaque region can easily migrate to a transparent region and, especially when the LCD shows at all display area,

15 an increase in leakage of light 21 becomes noticeable. Besides, when the distribution of the spacers 17 is not uniform, the display quality becomes distorted and a problem develops where the contrast decreases due to the leakage of light.

20   **SUMMARY OF THE INVENTION**

The present invention has been developed taking the above problems into consideration, comprising an active matrix LCD device and its manufacturing method, which have been made so that the amount of leakage of light is reduced

25 and the degradation of display quality is prevented to avoid spacer's moving into a transparent region when the device is shaken or impacted.

According to an aspect of the present invention, an LCD with at least one spacer (17) supporting two substrates that face each other is provided and is comprised of at least one spacer (17) which is positioned under an opaque region (9),

5 and at least one projection (6, 19) which is formed under the said opaque region (9), and on at least one of the inner-most surfaces of a first and a second substrate. An example of the LCD is illustrated in Fig. 7.

According to an aspect of the present invention, an LCD

10 with at least one spacer (17) supporting two substrates that face each other is provided and is comprised of at least one spacer (17) which is positioned under an opaque region (9), and a broken line of projections (6, 19) which are formed on at least one of the inner-most surfaces of a first and a

15 second substrate so as to encircle a transparent region.

According to an aspect of the present invention, a method of manufacturing an LCD is provided and is comprised of the following steps of depositing an insulation film (8) on a transparent substrate (10, 11); etching off an area of

20 the said insulation film 8 under an opaque region so as to form a ditch; and depositing an alignment layer (15) on the resultant surface of the said insulating film (8). An example of the method is illustrated in Figs. 20 and 21.

BRIEF DESCRIPTION OF DRAWINGS

25 The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description, when taken in conjunction

with the accompanying drawings, wherein:

Fig. 1 illustrates a plan view of a conventional lateral electric field-type LCD;

Fig. 2 illustrates a cross-sectional view of the conventional

5   LCD taken along a line JJ' in Fig. 1;

Fig. 3 illustrates a cross-sectional view of the conventional

LCD taken along a line KK' in Fig. 1;

Fig. 4 illustrates an enlarged schematic plan view of liquid

crystal molecules around the spacer in Figs. 2 and 3;

10   Fig. 5 illustrates an enlarged schematic plan view of liquid

crystal molecules around the spacer in Figs. 2 and 3;

Fig. 6 illustrates an enlarged schematic plan view of liquid

crystal molecules around the spacer in Figs. 2 and 3;

Fig. 7 illustrates a plan view of an LCD, according to the

15   first embodiment of the present invention;

Fig. 8 illustrates a cross-sectional view of the LCD taken

along a line AA' in Fig. 7;

Fig. 9 illustrates a cross-sectional view of the LCD taken

along a line BB' in Fig. 7;

20   Fig. 10 illustrates a plan view of an LCD, according to the

second embodiment of the present invention;

Fig. 11 illustrates a cross-sectional view of the LCD taken

along a line CC' in Fig. 10;

Fig. 12 illustrates a cross-sectional view of the LCD taken

25   along a line DD' in Fig. 10;

Fig. 13 illustrates a plan view of an LCD, according to the

third embodiment of the present invention;

Fig. 14 illustrates a cross-sectional view of the LCD taken along a line EE' in Fig. 13;

Fig. 15 illustrates a cross-sectional view of the LCD taken along a line FF' in Fig. 13;

5 Fig. 16 illustrates a plan view of an LCD, according to the fourth embodiment of the present invention;

Fig. 17 illustrates a cross-sectional view of the LCD taken along a line GG' in Fig. 16;

Fig. 18 illustrates a cross-sectional view of the LCD taken
10 along a line HH' in Fig. 16;

Fig. 19 illustrates a plan view of an LCD, according to the fifth embodiment of the present invention; and

Fig. 20 illustrates a cross-sectional view of the LCD taken along a line II' in Fig. 19.

15 Fig. 21 is a flowchart showing process steps for structuring a ditch that prevents each spacer from entering a transparent region.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

LCDs and their manufacturing methods, according to
20 several embodiments of the present invention, will be described with reference to the drawings. These LCDs are structured so as to prevent spacers within opaque regions of liquid crystal (e.g., areas of liquid crystal under a black matrix), which support two substrates facing each other and
25 allow the liquid crystal to fill the space between them, from moving and entering a transparent region.

(First embodiment)

Fig. 7 is a plan view of an active-matrix LCD, according to the first embodiment of the present invention. Fig. 8 is a partial cross-sectional view of the active-matrix LCD taken along a line AA' in Fig. 7, whereas Fig. 9 is a partial

5 cross-sectional view of the active-matrix LCD taken along a line BB' in Fig. 7.

As shown in these figures, a projection 6 is structured under part of a black matrix 9 and on the glass substrate 10 where TFTs are fabricated (hereafter, called a TFT substrate),

10 so as to encircle a transparent region. The projection 6 prevents any spacer 17 positioned within the light shielded regions of liquid crystal from entering the transparent region. The projection 6 is positioned in the vicinity of a data line 1, a scanning line 2, or a TFT 3 on/above the TFT

15 substrate 10, which have been structured under the black matrix 9 on the underside of the glass substrate 11.

As shown in Fig. 8, the projection 6, which is made of a metal pattern, is fabricated at a region overlapped with a part of the black matrix 9 and also on a common electrode 4, which is positioned in the vicinity of the data line 1. The

20 material of the projection 6 can be alternatively made of a metal such as Cr, Al, or Mo, or an insulating material such as SiO_2 or SiNx. The formation of the projection 6 can be done during the fabrication of TFTs on the TFT substrate.

25 Alternatively, the projection 6 can be made of, for example, a resin and formed after the TFTs have been fabricated on the TFT substrate. An alignment layer 15 is then deposited on

the surface where the projection 6 has been fabricated.

The distance between the top surface of the alignment layer 15 over the projection 6 and the undersurface of the alignment layer 16 on the opposite facing substrate 11 is

5   shorter than that between the top surface of the alignment layer 15 on the data line 1 and the undersurface of the alignment layer 16 under the opposite facing substrate 11. The width of the projection 6 is equal to or less than the diameter of the spacer 17. Namely, if the diameter of the

10 spacer 17 is equal to $4\,\mu$m, the width of the projection 6 is equal to or less than $4\,\mu$m.

Besides, as shown in Fig. 9, the distance between the top surface of the alignment layer 15 covering the projection 6 and the underside of the alignment layer 16 on the opposite

15 facing substrate 11 is shorter than the distance between the top surface of the alignment layer 15 on the TFT 3 and the underside of the alignment layer 16 on the opposite facing substrate 11. The width of the projection 6 is equal to or less than the diameter of the spacer 17 in the same form as

20 described above. The projection 6 can be made of a material identical to that of a protection/insulation film 8 and formed by the following process: First, depositing a thick protection/insulation film 8 on the resultant surface including the surfaces of the data line 1, an interlayer

25 insulation film 7 and a scanning line 3 after TFTs have been fabricated; Secondly,   selectively   etching   off   a

protection/insulation film 8 so as to leave the area of the projection 6; Lastly, depositing the alignment layer 15 over the entire resultant surface.   The projection 6 can be alternatively made of a material such as a resin and be

5   formed by the following process: First, depositing a protection/insulation film 8 on the resulting surface including the surfaces of data line 1, an interlayer insulation film 7, and a scanning line 3 after TFTs have been fabricated; Secondly, depositing any one of the materials for

10 the projection 6 as described above on top of the protection/insulation film 8; Thirdly, selectively etching of the deposited material so as to leave the area of the projection 6; Lastly, depositing the alignment layer 15 all over the resultant surface.   Afterwards, a plurality of

15 spacers are distributed throughout the resultant surface. The fabricated opposite facing substrate, as illustrated in the upper area of Figs. 8 and 9, is then fixed on top of the multiple spacers, and liquid crystal 18 is injected into the space between the two fabricated substrates.

20   The difference between the said distance from the top surface of the alignment layer 15 on the TFT 3, the data line 1 and the scanning line 2, to the undersurface of the alignment layer 16 on the opposite facing substrate 11, and the distance from the top surface of the alignment layer 15

25 on top of the projection 6 to the undersurface of the alignment layer 16 on the opposite facing substrate 11 is equal to or longer than approximately 1 % the length of the

diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %. In other words, the height of each projection 6 is equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %. This prevents each spacer 17 positioned within the opaque regions (i.e., under the black matrix 9) from climbing over the projection 6 and then entering a transparent region of liquid crystal molecules.

In summary, according to the first embodiment of the present invention, the projection 6 is structured on the TFT substrate 10, with the distance between the top surface of the alignment layer 15 covering the projection 6 and the underside of the alignment layer 16 on the opposite facing substrate 11 being shorter than the distance between the top surface of the alignment layer 15 on the data line 1, the scanning line 2 and the TFT 3, and the undersurface of the alignment layer 16 on the opposite facing substrate 11.

Due to this structure, even if a certain pressure or impact happens to be applied onto the LCD panel, it is difficult for any spacer 17, which is positioned within the opaque regions or under the black matrix 9, to climb over the projection 6, and then enter a transparent region; therefore, the leakage of light decreases, and the contrast is improved. Also, a possible unevenness in display quality due to the areas of the leakage of light being unevenly distributed is decreased. Furthermore, the panel becomes more durable

against certain vibrations and impacts: Even if certain vibrations and impacts happen to hit the fabricated active-matrix LCD after it has been inspected, they cannot damage it. As a result, high display quality is provided.

5   Incidentally, Fig. 7 illustrates a continuously extending projection 6 positioned along the black matrix extensions. However, the present invention is not limited to this. Alternatively, the projection 6 can be made up of multiple, intermittent pieces positioned along the extensions

10 of the black matrix 9. In other words, a broken line of projections can be formed on the inner-most surface of the TFT substrate 10 so as to encircle the transparent regions. The length of each gap in the broken line of projections is shorter than the diameter of the spacer 17.

15 (Second embodiment)

Next, an LCD, according to the second embodiment of the present invention, will be described while referencing Figs. 10 to 12. Fig. 10 illustrates a plan view of the LCD of the second embodiment. Fig. 11 illustrates a cross-sectional

20 view of the LCD taken along a line CC' in Fig. 10; whereas Fig. 12 illustrates a cross-sectional view of the LCD taken along a line DD' in Fig. 10.

In the LCD of the second embodiment, as shown in Figs. 10 to 12, a projection 19 is structured on the undersurface

25 of an opposite facing substrate 11 under part of a black matrix 9, instead of on the top surface on a TFT substrate 10, as in the first embodiment. During the fabrication of the

opposite facing substrate 11, the projection 19 is structured during the formation of the first colored layer 12 and an over-coating film 14. The projection 19 is made of a material identical to that of a over-coating film 14, and can

5 be formed by the following process: First, depositing a thick over-coating film on the underside of the colored layers including the first and the second colored layers 12 and 13, which have been deposited on the undersides of the black matrix 9 and the opposite facing glass substrate 11; Secondly,

10 selectively etching off the deposited film so as to leave the area of the projection 19; Lastly, depositing the alignment layer 16 over the entire resultant surface. The projection 19 can be alternatively formed by the following process: First, depositing an over-coating film 14 on the underside of

15 the colored layers including the first and the second colored layers 12 and 13, which have been deposited on the undersides of the black matrix 9 and the opposite facing glass substrate 11; Secondly, depositing a material for the projection 19 on top of the deposited over-coating film 14; Thirdly,

20 selectively etching off the deposited material so as to leave the area of the projection 19; Lastly, depositing the alignment layer 16 over the entire resultant surface of both the over-coating film 14 and the projection 19.

Also, the projection 19 and the over-coating film 14, as

25 shown in Fig. 11, are simultaneously formed under the black matrix 9 on the opposite facing substrate 11. The distance between the undersurface of the alignment layer 16 on top of

the projection 19 and the top surface of the alignment layer 15 on the TFT substrate 10 is shorter than that between the top surface of the alignment layer 15 on the data line 1 and the undersurface of the alignment layer 16 on the opposite

5 facing substrate 11. The width of the projection 19 is equal to or less than the diameter of the spacer 17. That is, if the diameter of the spacer 17 is equal to 4 μm, the width of the projection 19 is accordingly equal to or less than 4 μm.

As shown in Fig. 12, the projection 19 is structured

10 under part of the black matrix 9 in the vicinity horizontal to the scanning line 2 and the TFT 3. The distance between the undersurface of the alignment layer 16 on the underside of the projection 19 and the top surface of the alignment layer 15 on the TFT substrate 10 is shorter than that between

15 the top surface of the alignment layer 15 on both the scanning line 2 and TFT 3, and the undersurface of the alignment layer 16 on the opposite facing substrate 11. The width of the projection 19 is equal to or less than the diameter of the spacer 17, as in the same format as described

20 above.

The difference between the distance from the top surface of the alignment layer 15 on the data line 1, the scanning line 2, and the TFT 3, to the undersurface of the alignment layer 16 at the opposite facing substrate 11, and the

25 distance from the undersurface of the alignment layer 16 on the underside of the projection 19 to the top surface of the

alignment layer 15 at the TFT substrate 10 is, as is in the same format as the first embodiment, equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than

5 approximately 2 %. In other words, the height of each projection 19 is equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %.

10 In summary, according to the second embodiment of the present invention, the projection 19 is structured on the opposite facing glass substrate 11 with the distance between the undersurface of the alignment layer 16 on the underside of the projection 19 and the top surface of the alignment

15 layer 15 on the TFT substrate 10 being shorter than that between the top surface of the alignment layer 15 on the data line 1, the scanning line 2, and the TFT 3, and the undersurface of the alignment layer 16 on the opposite facing substrate 11.

20 Due to this format, even if a certain pressure or an impact happens to hit the LCD panel of the second embodiment, it is difficult for any spacer 17 positioned within the opaque regions (i.e., under the black matrix or on either the data line 1, the scanning line 2, or the TFT 3) to enter a

25 transparent region. This prevents a possible increase in leakage of light caused by the entry of each spacer from occurring. As a result, the leakage of light decreases, and

the contrast is improved. Also, the uneven display resulting from areas of the leakage of light being unevenly distributed is reduced. Furthermore, the panel becomes more durable against certain vibrations and impacts: Even if certain

5 vibrations and impacts happen to hit the fabricated, active-matrix LCD after it has been inspected, they cannot damage it.

Incidentally, Fig. 10 illustrates a continuously extending projection 19 positioned along the black matrix extensions. However, the present invention is not limited to

10 this. Alternatively, the projection 19 can be made up of multiple, intermittent pieces positioned along the extensions of the black matrix 9. In other words, a broken line of projections can be formed on the inner-most surface of the TFT substrate 11 so as to encircle the transparent regions.

15 The length of each gap in the broken line of projections is shorter than the diameter of the spacer 17.

(Third embodiment)

Next, an LCD, according to the third embodiment of the present invention, will be described while referencing Figs.

20 13 to 15. In brief, the LCD of the third embodiment is attained by combining the structures of the first and the second embodiment together. Fig. 13 illustrates a plan view of the LCD of the third embodiment. Fig. 14 illustrates a cross-sectional view of the LCD taken along a line EE' in Fig.

25 13; whereas Fig. 15 illustrates a cross-sectional view of the LCD taken along a line FF' in Fig. 13.

According to the LCD of the third embodiment, as shown

in Figs. 14 and 15, two independent projections 6 and 19 are structured on the respective TFT glass substrate 10 and opposite facing glass substrate 11. The fabrication processes for the two projections 6 and 19 are identical to those in the first and second embodiment.

As shown in Fig. 14, the projection 6, which is made of metal pattern, is structured under part of the black matrix 9, and on the common electrode 4 on top of the TFT substrate 10. On the other hand, the projection 19 is structured to be part of the over-coating film 14 on the opposite facing substrate 11, under the same part of the black matrix 9. The projections 6 and 19 on the respective TFT substrate 10 and opposite facing substrate 11 face each other. The distance between the top surfaces of the alignment layers 15 and 16 on top of the respective projections 6 and 19 is shorter than the distance between the top surface of the alignment layer 15 on the data line 1 and the undersurface of the alignment layer 16 on the opposite facing substrate 11.

With this format, the heights of the respective projections 6 and 19 can be half of those of the respective first and second embodiments. The widths of the respective projections 6 and 19 are equal to or less than the diameter of the spacer 17 in the same format as the first and the second embodiment.

Incidentally, the present invention is not limited to the arrangement of the projections 6 and 19 facing each other and being positioned under a part of the black matrix 9. In

other words, each of the projections 6 on the TFT glass substrate 10 can be positioned far from each of the projections 19 on the facing glass substrate 11 as long as they are positioned under part of the black matrix 9, so as

5 to prevent each spacer 17 positioned under the black matrix 9 from climbing over and entering an optical transparent region. In this case, the distance between the top surface of the alignment layer 15 on top of each projection 6 and the undersurface of the alignment layer 16 on the facing glass

10 substrate 11, and the distance between the undersurface of the alignment layer 16 on top of each projection 19 and the top surface of the alignment layer 15 on the TFT glass substrate 10 should both be shorter than the distance between the top surface of the alignment layer 15 on the data line 1

15 and the undersurface of the alignment layer 16 on the facing glass substrate 11.

Due to the aforementioned arrangement of the projections 6 and 19 facing each other, the number of the projections is doubled the number of those in each of the first and the

20 second embodiments. This prevents each spacer positioned under the black matrix 9 from climbing over the projections and entering a transparent region.

Next, other projections 6 and 19 positioned near a TFT 3 will be described while referencing Fig. 15. As shown in Fig.

25 15, the projection 6, which is made of a metal pattern, is structured under part of the black matrix 9 and on the common electrode 4 formed near the scanning line 2 and TFT 3 on the

TFT glass substrate 10. On the other hand, the projection 19, which is made of the same material as that of the over-coating film 14, is structured under part of the black matrix 9 on the undersurface of the opposite facing glass substrate

5   11, and is also positioned, in the horizontal direction, near the data line 1.

The projections 6 and 19 on the respective TFT glass substrate 10 and opposite facing substrate 11 face each other. The distance between the alignment layers 15 and 16 on the

10   tops of the respective projections 6 and 19 is shorter than the distance between the top surface of the alignment layer 15 on both the scanning line 2 and the TFT 3, and the undersurface of the alignment layer 16 on the opposite facing glass substrate 11.   This allows the heights of the

15   respective projections 6 and 19 to be half the length of those of the first and the second embodiment. The widths of the respective projections 6 and 19 are equal to or less than the diameter of the spacer 17 in the same format as the first and the second embodiment.

20   Incidentally, up to this point, it has been explained that the projections 6 and 19 in Fig. 15 face each other. However, the present invention is not limited to this. Alternatively, each projection 6 can be positioned not facing each projection 19. In this case, the distance between the

25   top surface of the alignment layer 15 on top of each projection 6 and the undersurface of the alignment layer 16 on the facing glass substrate 11 and the distance between the

undersurface of the alignment layer 16 on top of each projection 19 and the top surface of the alignment layer 15 on the TFT glass substrate 10 should be both shorter than the distance between the top surface of the alignment layer 15 on

5   both the scanning line 2 and TFT 3, and the undersurface of the alignment layer 16 on the facing glass substrate 11.

Due the structure of the projections 6 and 19 on the respective TFT glass substrate 10 and facing glass substrate 11, the total number of projections 6 and 19 is each double

10   those of the first and the second embodiment. This allows a surer prevention of each spacer 17 under the black matrix 9 from entering an optical transparent region.

The difference between the distance from the top surface of the alignment layer 15 on the data line 1, the scanning

15   line 2, and the TFT 3, to the undersurface of the alignment layer 16 on the opposite facing substrate 11, and the distance from the undersurface of the alignment layer 16 on the underside of the projection 19 to the top surface of the alignment layer 15 on the TFT substrate 10 is, as is in the

20   same form as the first embodiment, equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %. Also, the difference between the former distance and the distance between the top surface of the

25   alignment layer 15 on top of the projection 6 and the undersurface of the alignment layer 16 at the opposite facing substrate 11 is equal to or longer than approximately 1 % the

length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %.

Due to this format described above, even if a certain pressure or impulse happens to be applied onto the LCD panel of the third embodiment, each spacer 17 positioned under the black matrix and on either the data line 1, the scanning line 2, or the TFT 3, is prevented from moving, climbing over, and entering a transparent region. This prevents a possible increase in the total amount of leakage of light due to the entry of each spacer 17. As a result, the leakage of light decreases, and the contrast is improved. Also, the uneven display resulting from areas of the leakage of light being unevenly distributed is reduced. These advantages allow the provision of an active-matrix LCD with high reliability.

Incidentally, Fig. 13 illustrates continuously extending projections 6 and 19 positioned along the black matrix extensions. However, the present invention is not limited to this. Alternatively, the projections 6 and 19 can be made up of multiple, intermittent pieces positioned along the extensions of the black matrix 9.

(Fourth embodiment)

Next, an LCD, according to the fourth embodiment of the present invention, will be described while referencing Figs. 16 to 18. In brief, the LCD of the fourth embodiment is attained by structuring different types of projections on the TFT glass substrate 10 from the projections 6 and 19 in the first to the third embodiments. Fig. 16 illustrates a plan

view of the LCD of the fourth embodiment. Fig. 17
illustrates a cross-sectional view of the LCD taken along a
line GG' in Fig. 16; whereas Fig. 18 illustrates a cross-
sectional view of the LCD taken along a line HH' in Fig. 16.

5   As shown in Figs. 17 and 18, each of the aforementioned
projections or bumps are structured by positioning a common
electrode 4 on top of the TFT glass substrate 10. This
causes the distance between the top surface of each bump
caused by the common electrode 4, and the underside of the
10   opposite facing glass substrate 11 to be shorter than the
distance between the top surface of the alignment layer 15 on
the data line 1, the scanning line 2, and the TFT 3, and the
undersurface of the alignment layer 16 of the opposite facing
glass substrate 11.

15   The difference between the distance from the top surface
of the alignment layer 15 on the data line 1, the scanning
line 2 and the TFT 3, to the undersurface of the alignment
layer 16 of the facing glass substrate 11, and the distance
from the top surface of the bump on the common electrode 4 to
20   the undersurface of the alignment layer 16 of the opposite
facing glass substrate 11 is equal to or longer than
approximately 1 % the length of the diameter of the spacer 17,
and it is preferable that it be equal to or longer than
approximately 2 %. In other words, the height of each bump
25   is equal to or longer than approximately 1 % the length of
the diameter of the spacer 17, and it is preferable that it
be equal to or longer than approximately 2 %. This allows

the prevention of the spacer 17 from moving and entering an optical transparent region. In addition, each bump can be formed more easily by structuring the common electrode 4 on the TFT substrate 10 than structuring the projections 6 and

5 19 according to the first through third embodiments. Accordingly, each bump can be fabricated by shortened process steps.

Due to the form of the LCD of the fourth embodiment, even if a certain pressure or impulse happens to be applied

10 onto the LCD panel, each spacer 17 under the black matrix 9 and on either the data line 1, the scanning line 2, or the TFT 3, is prevented from moving and entering a transparent region. This prevents a possible increase in a total leakage of light due to each spacer 17. As a result, the displaying

15 contrast is improved. Also, the uneven display resulting from areas of leakage of light being unevenly distributed is reduced. These advantages allow the provision of an active-matrix LCD with high reliability.

(Fifth embodiment)

20 Next, an LCD, according to the fifth embodiment of the present invention, will be described while referencing Figs. 19 to 20. In this embodiment, in place of forming each projection or bump, which prevents each spacer 17 within opaque regions (i.e., under the black matrix 9) from entering

25 an optical transparent region, a ditch is formed on the inner surface of either the TFT glass substrate 10 or the facing glass substrate 11, so as to confine each spacer 17 within it,

as shown in Fig. 20. Fig. 19 illustrates a plan view of the LCD of the fifth embodiment; whereas Fig. 20 illustrates a cross-sectional view of the LCD taken along a line II' in Fig. 19.

5   In Fig. 20, the ditch where each spacer 17 is confined is formed on the inner surface of the TFT substrate 10 under the black matrix 9. As shown in the flowchart in Fig. 21, the ditch is formed by the following process steps: First, a protection/insulation film 8 is deposited over the surface of
10   both the data line 1 and common electrode 4, which have been formed on top of the TFT glass substrate 10 (step S1); Secondly, an area of the deposited protection/insulation film 8 under the black matrix 9, where at least one spacer 17 is later positioned, is etched off so as to form a ditch (step
15   S2); Thirdly, interlayer insulation film 7 is deposited onto the resultant surface (step S3); Fourthly, an alignment layer 15 is deposited onto the resultant surface (step S4); Fifthly, a spacer 17 is placed within the resultant ditch (step S5); Lastly, the opposite facing substrate 11 with the black
20   matrix 9, colored layers 12 and 13, over-coating film 14, and alignment layer 16, which have been arranged in the format as shown in Fig. 20, is fixed onto the spacers 17 so as to face the TFT glass substrate 10. With this structure, each spacer 17 in the ditch cannot go over the wall 22 of the ditch, thus
25   being confined within it.

The distance between the top surface of the alignment layer 15 on the common electrode 4 and the inner surface of

the alignment layer 16 on the opposite facing glass substrate 11 is shorter than the distance between the top surface of the alignment layer 15 on the signal 1 and the inner surface of the alignment layer 16 on the facing glass substrate 11,

5   as shown in Fig. 20.   The difference between the former distance and the latter distance is equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %.   This allows the prevention of the spacer

10   17 from moving and entering an optical transparent region. As a result, even if a certain pressure or impulse happens to be applied onto the LCD, each spacer 17 within the on ditch is prevented from moving and entering a transparent region. This prevents an increase in total leakage of light around

15   each spacer 17.   As a result, the uneven display resulting from areas of the leakage of light being unevenly distributed is reduced. These advantages allow the provision of an active-matrix LCD with high reliability and high displaying quality.

20   In the above description, the case where the ditch is formed at the TFT glass substrate 10 is explained.   However, the present invention is not limited to this.   A ditch that confines each spacer 17 within it can be naturally formed on the opposite facing glass substrate 11.

25   Furthermore, in the above description, the case where the present invention is used for a lateral electric field-type/TFT active matrix LCD is explained. However, the present

invention is not limited to this. The structure with the projections, the bumps, and the ditches as described above, according to the present invention, can also be naturally used for the simple matrix TN(twisted nematic)- and STN(super

5   twisted nematic)-type LCD, the ferroelectric LCD, the polymer disbursed LCD, etc. The lateral electric field-type active matrix LCD, in particular, often uses the normally black system (i.e., black is displayed while no voltage is applied), and may easily develop leakage of light due to the disarray

10   in liquid crystal molecule orientation around each spacer. This problem of leakage of light can be prevented by utilizing the aforementioned structures according to the present invention.

LCDs, and their manufacturing methods, according to the

15   present invention, have been described in connection with several preferred embodiments. It is to be understood that the subject matter encompassed by the present invention is not limited to that specified embodiment. On the contrary, it is intended to include all alternatives, modifications,

20   and equivalents as can be included within the spirit and scope of the following claims.

WHAT IS CLAIMED IS:

1. A liquid crystal display (LCD) comprising at least one spacer (17) which is positioned under an opaque region (9), and at least one projection (6, 19) which is formed under the

5 said opaque region (9), and on at least one of the inner-most surfaces of a first and a second substrate.

2. The LCD, according to claim 1, wherein the said projection (6, 19) is formed under the said opaque region (9), and on at least one of the inner-most surfaces of the said first

10 substrate and the second substrate, in a format of creating a wall around a transparent region so that the said at least one spacer (17) can not enter the said transparent region.

3. The LCD, according to claim 1, wherein the said opaque region (9) is made of a black matrix.

15 4.The LCD, according to claim 1, wherein the height of the said projection (6, 19) is equal to or longer than approximately 1 % the length of the diameter of the said spacer (17).

5. The LCD, according to claim 1, wherein the width of the

20 said projection (6, 19) is equal to or shorter than the diameter of the said spacer (17).

6. The LCD, according to claim 1, wherein the said projection (6, 19) is formed by structuring a bumpy layer under an alignment layer (15, 16).

25 7. The LCD, according to claim 1, wherein the said projection (6, 19) is formed by structuring a common electrode (4).

8. The LCD, according to claim 1, wherein one of the said at

least one projection (6) formed on the inner-most surface of the said first substrate faces another one of the said at least one projection (19) formed on the inner-most surface of the said second substrate.

5 9. The LCD, according to claim 8, wherein the heights of that one of the said at least one projection (6) formed on the inner-most surface of the said first substrate and that another one of the said at least one projection (19) formed on the inner-most surface of the said second substrate are

10 each equal to half of a value that is equal to or longer than approximately 1 % the length of the diameter of the said spacer (17).

10. An LCD comprising at least one spacer (17) which is positioned under an opaque region (9), and a broken line of

15 projections (6, 19) which are formed on at least one of the inner-most surfaces of a first and a second substrate so as to encircle a transparent region.

11. The LCD, according to claim 10, wherein the length of each gap in the said broken line of projections (6, 19) is

20 shorter than the diameter of the said spacer (17).

12. The LCD, according to claim 1, wherein the said spacer (17) is movable within the space between the said two substrates when a certain pressure is applied onto at least one of the said two substrates.

25 13. The LCD, according to claim 1, wherein the space between the said two substrates is filled with liquid crystal molecules, to which a lateral electric field is applied so as

to rotate the said liquid crystal molecules.

14. The LCD, according to claim 1, wherein the space between the said two substrates is filled with liquid crystal molecules, to which a vertical electric field is applied so as to rotate the said liquid crystal molecules.

15. A method of manufacturing an LCD, comprising: depositing an insulation film (8) at a transparent substrate (10, 11); etching off an area of the said insulation film 8 under an opaque region so as to form a ditch; and depositing an alignment layer (15) on the resultant surface of the said insulating film (8).

16. The method, according to claim 15, wherein the wall (22) of the said ditch is high enough to confine a spacer (17) positioned in the said ditch.

17. The method, according to claim 15, wherein the said depositing of the said insulation film (8) is performed on the surface resulting from fabricating thin film transistors on the said transparent substrate (10).

ABSTRACT

In an LCD, according to an embodiment of the present invention, a projection 6 is structured on top of insulation layer 8 on a TFT glass substrate 10 and under part of a black

5   matrix 9. The projection 6 encircles the transparent region in each pixel so that a spacer 17 cannot climb over the projection 6 and enter the transparent region even though a certain pressure is applied onto the substrates 10 and 11. The width of the projection 6 is equal to or less than the

10 diameter of the spacer 17. The height of the projection 6 is equal to or longer than approximately 1 % the length of the diameter of the spacer 17, and it is preferable that it be equal to or longer than approximately 2 %.

Fig.1
Prior Art
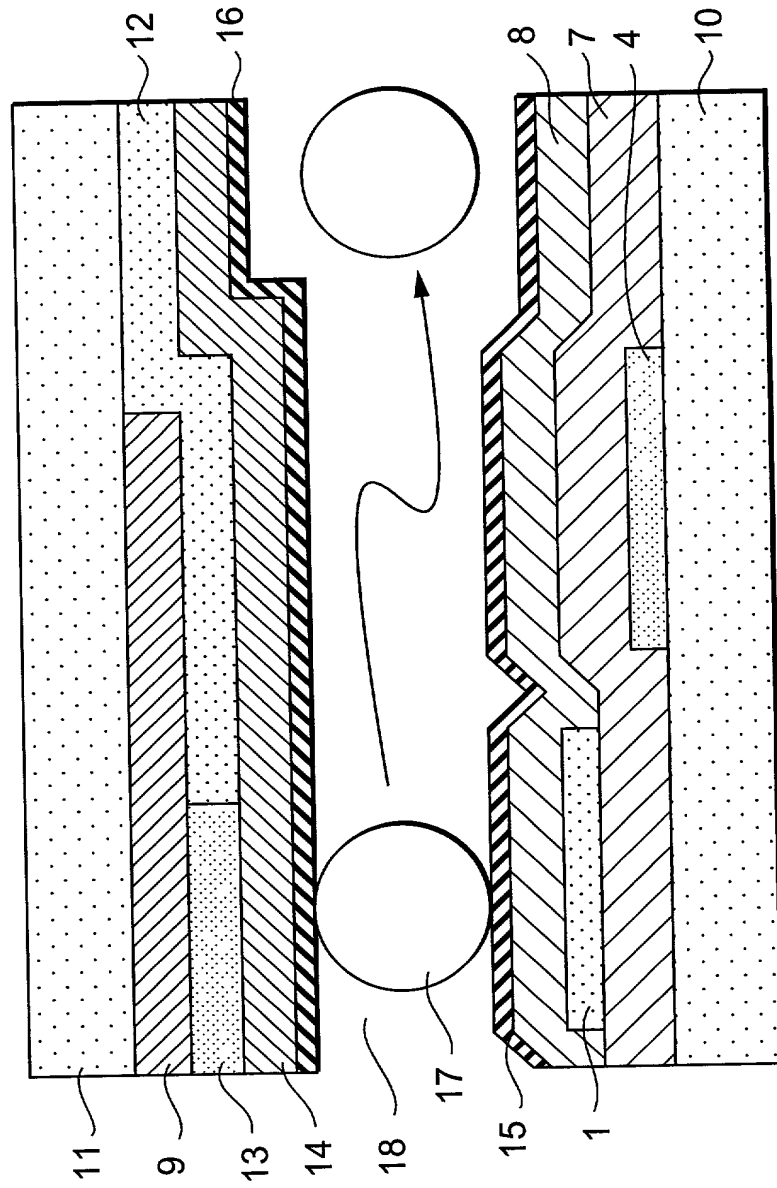
Fig.2
Prior Art

Fig.3
Prior Art

Fig.4
Prior Art

21   17 20
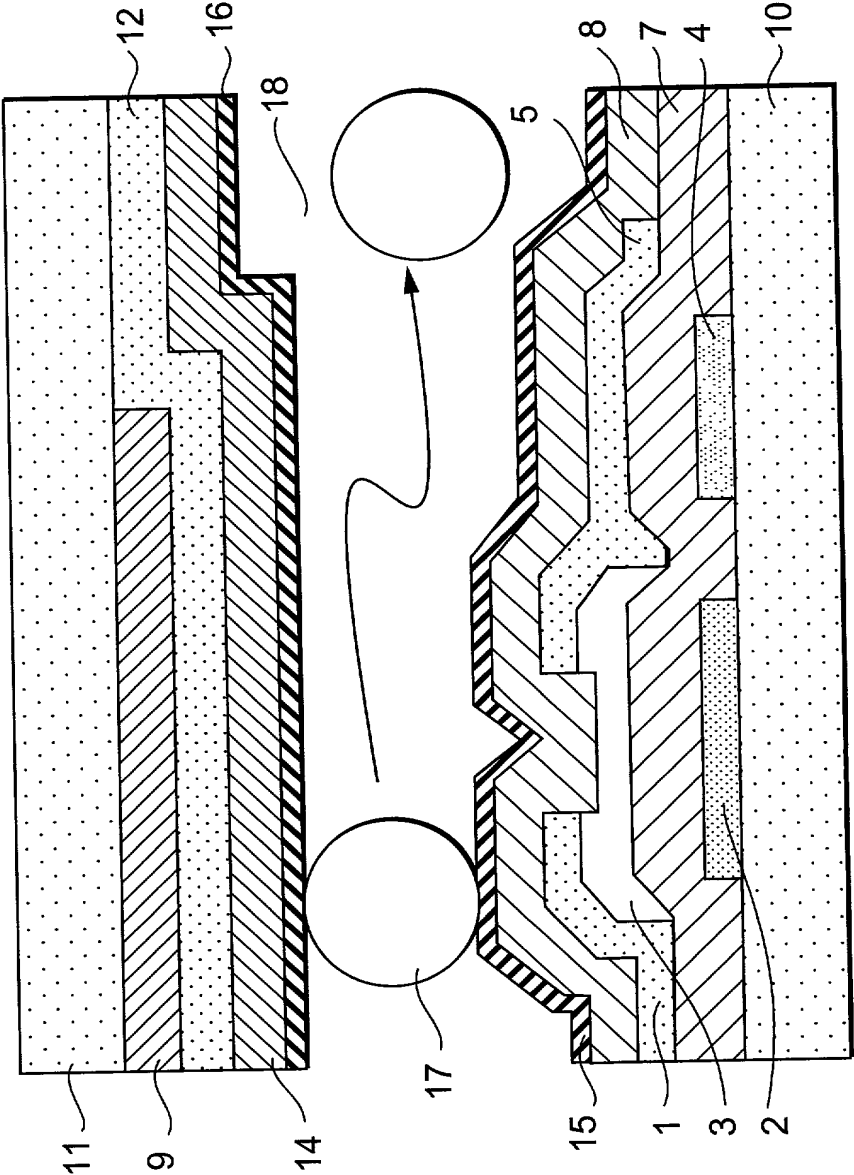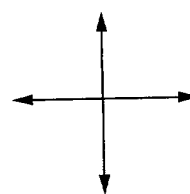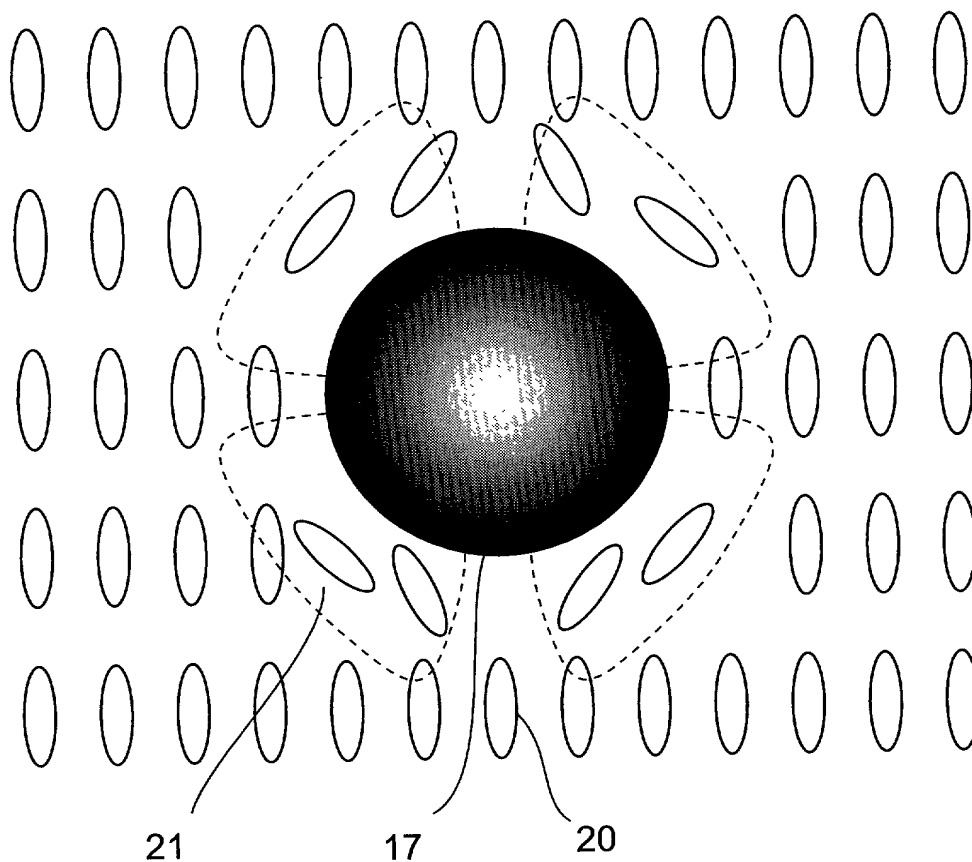
ABSORPTION RUBBING
AXES   DIRECTION

Fig.5
Prior Art

21

20

17

ABSORPTION   RUBBING
AXES   DIRECTION

Fig.6
Prior Art

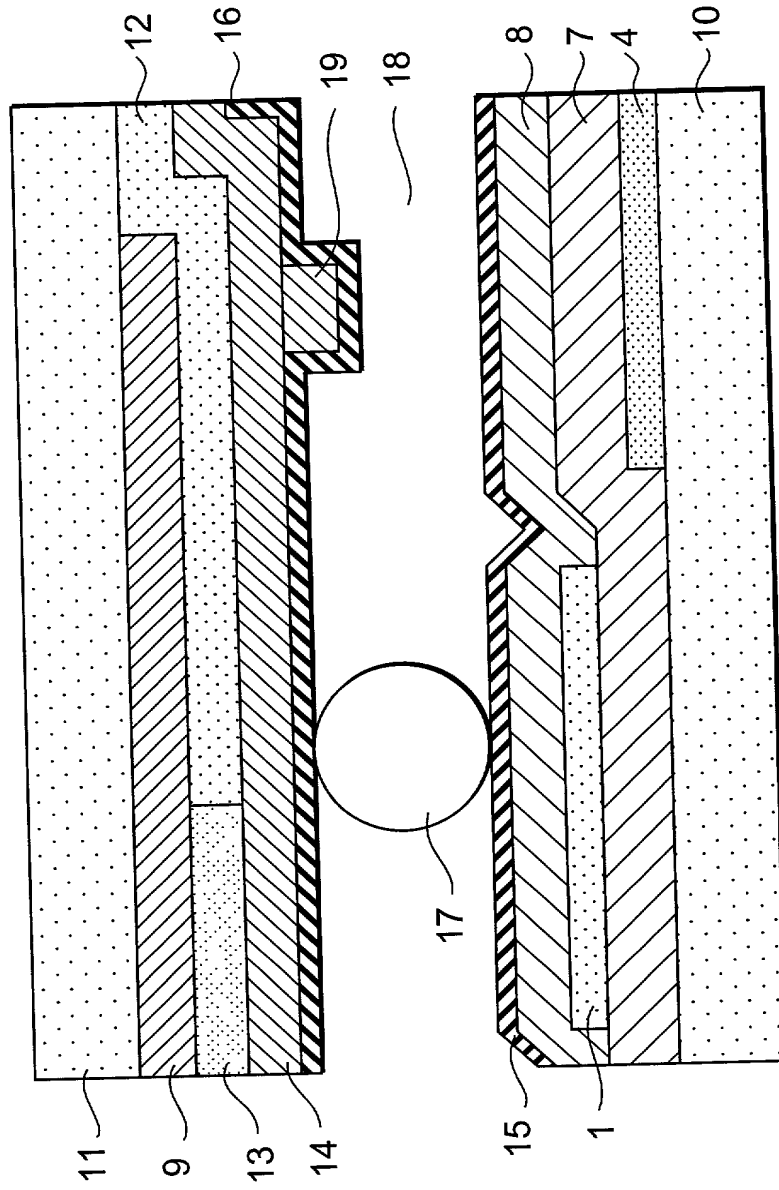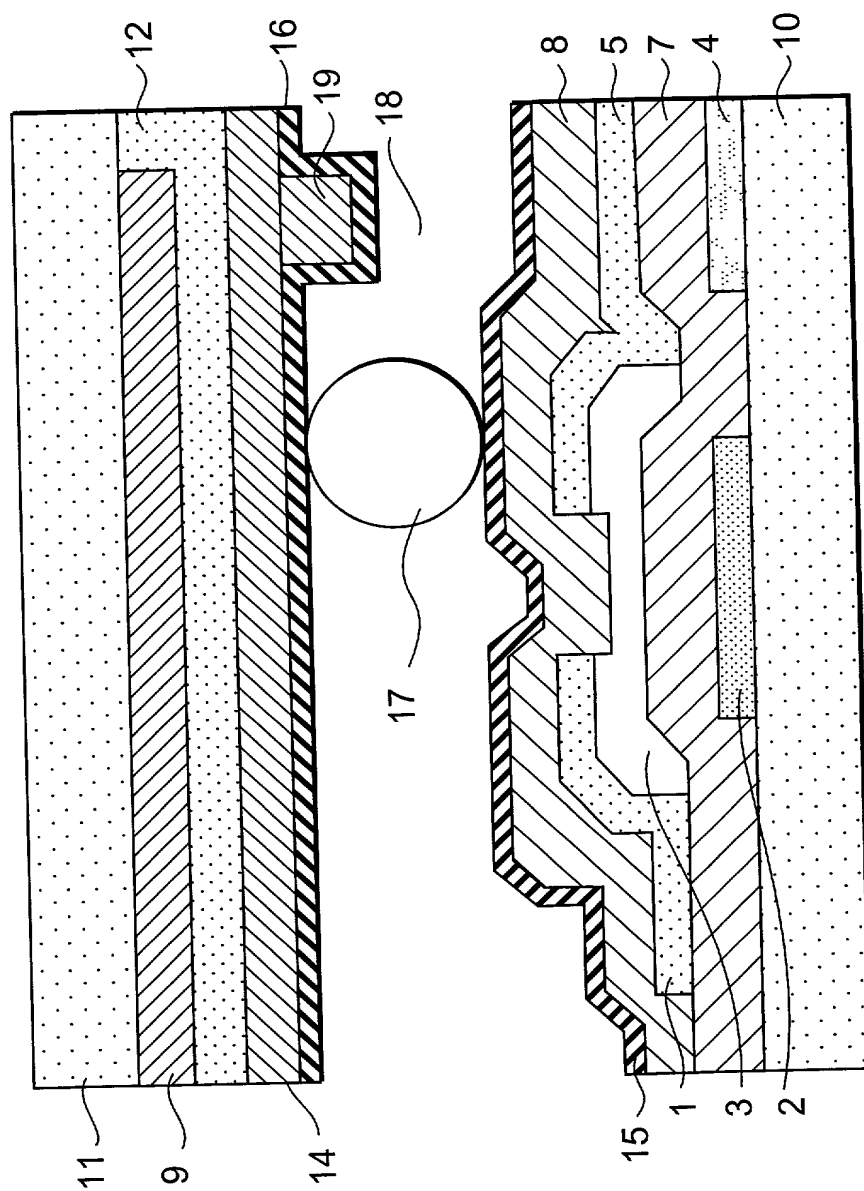21   17   20

ABSORPTION   RUBBING
AXES   DIRECTION
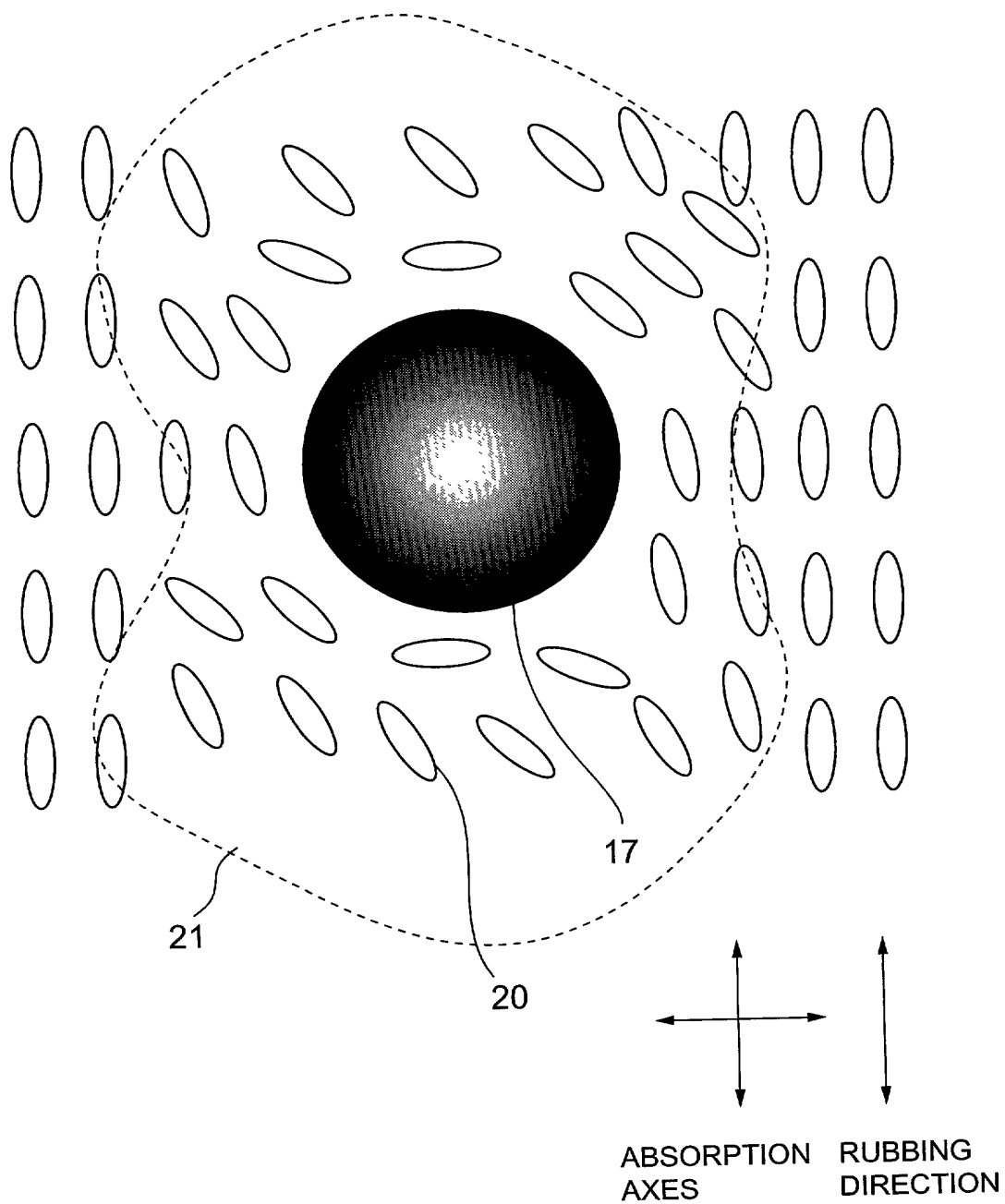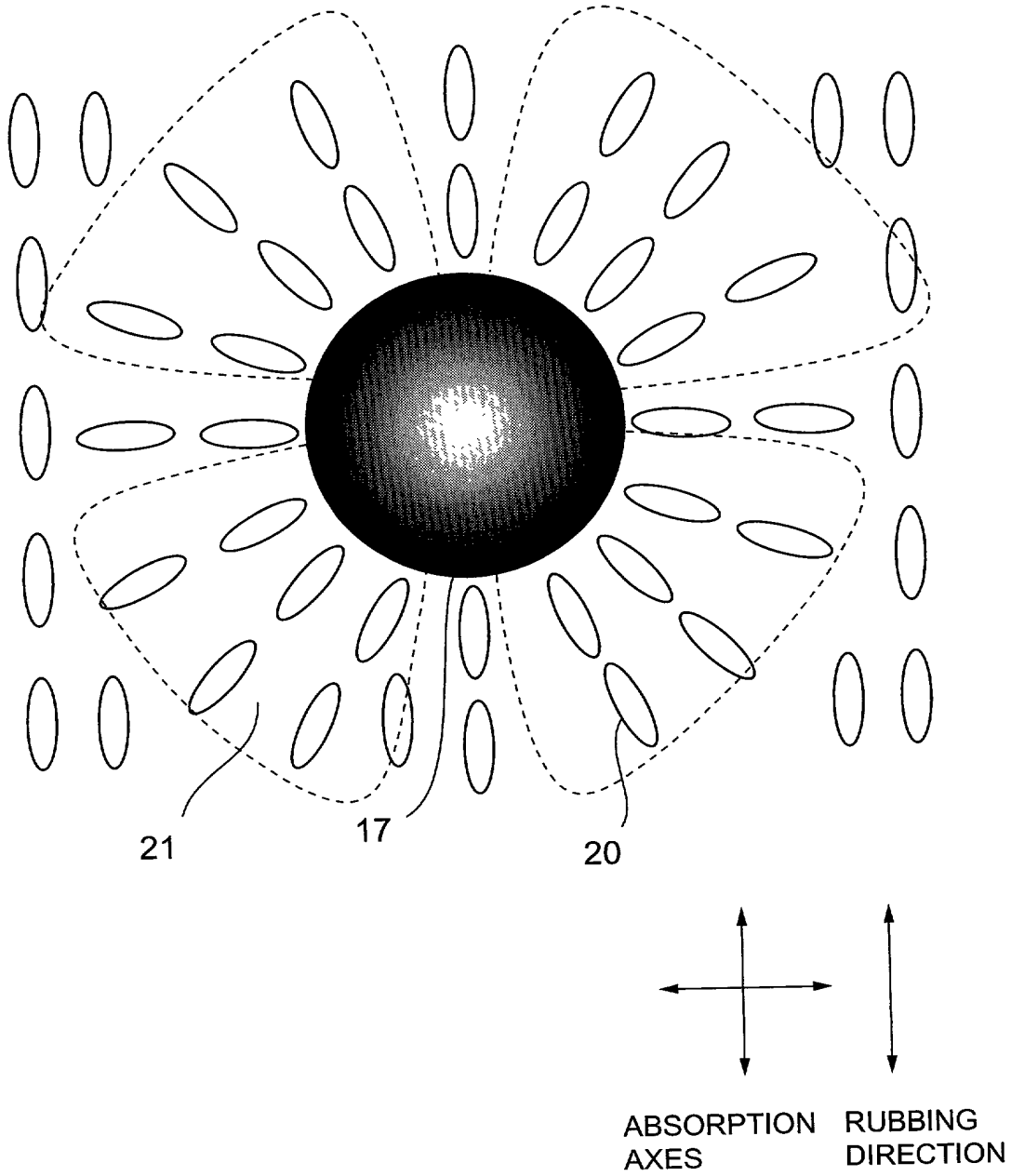
Fig.7
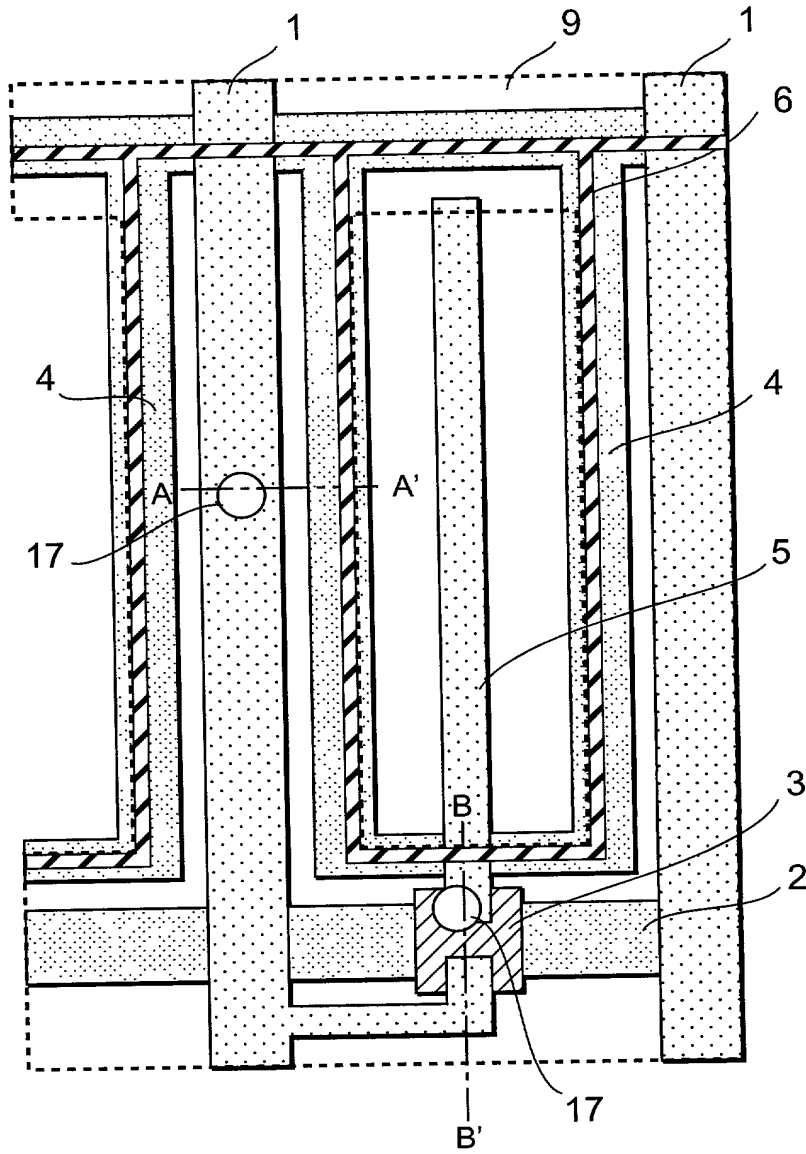
Fig.8
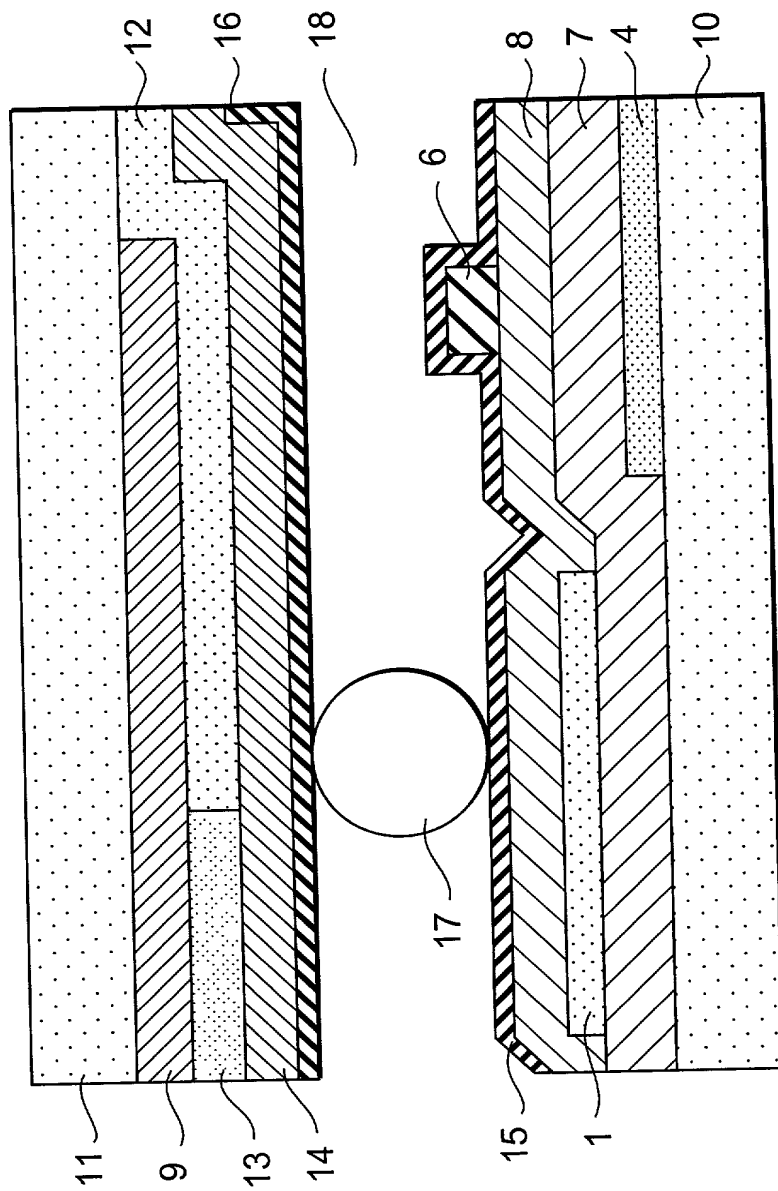
Fig.9
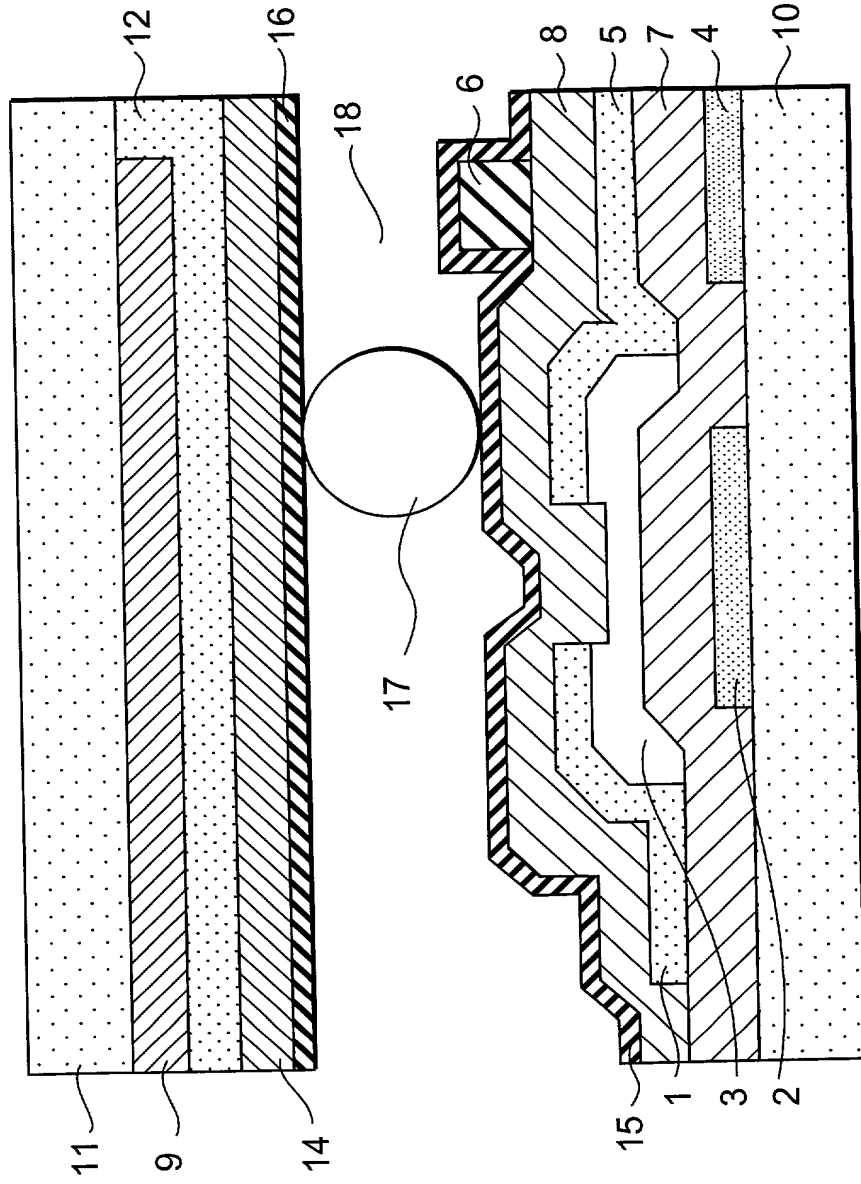
Fig.10
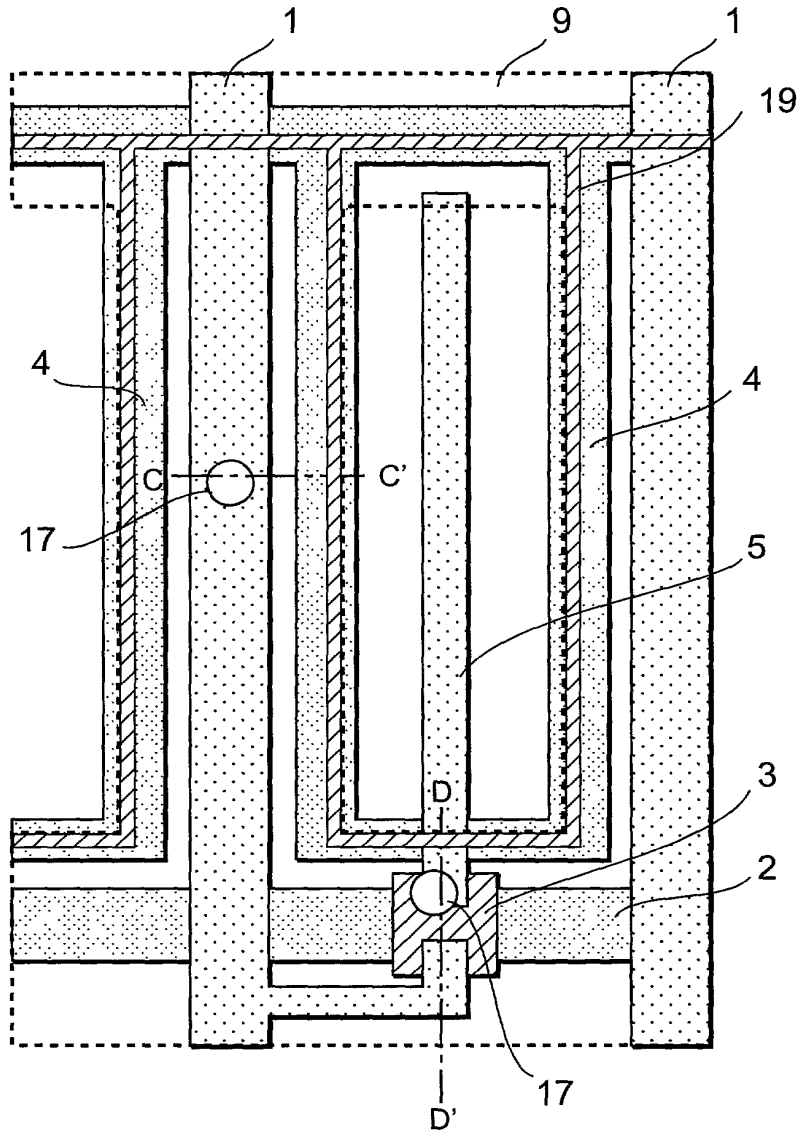
Fig.11

Fig.12

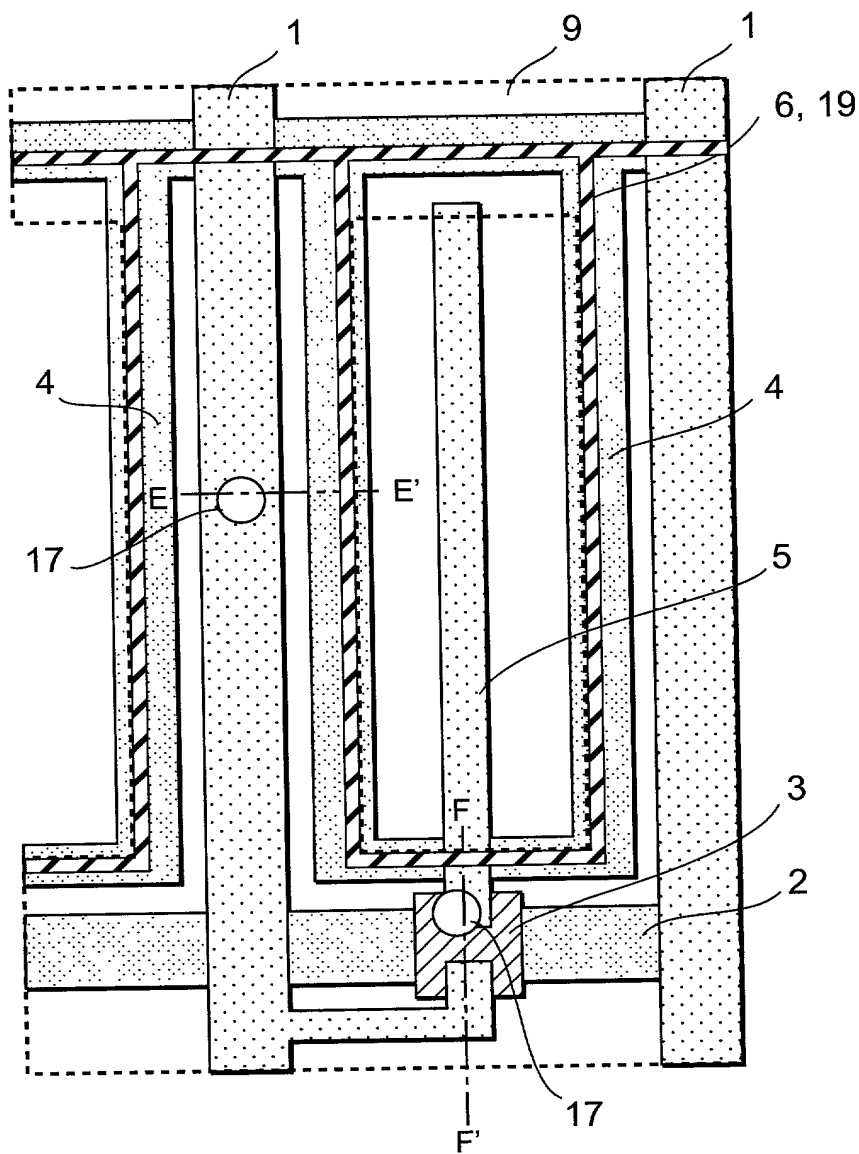# Fig.13

Fig.14

Fig.15

Fig.16

Fig.17

Fig.18

Fig.19

Fig.20

Fig.21

```
        ┌─────────────┐
        │    START    │
        └─────────────┘
               │
┌──────────────────────────────────────┐
│  DEPOSIT PROTECTION/INSULATION FILM   │──── S1
└──────────────────────────────────────┘
               │
┌──────────────────────────────────────┐
│  ETCH OFF AREA OF DEPOSITED           │
│  PROTECTION/INSULATION FILM 8         │──── S2
│  TO FORM DITCH                        │
└──────────────────────────────────────┘
               │
┌──────────────────────────────────────┐
│  DEPOSIT INTERLAYER INSULATION FILM 7 │──── S3
└──────────────────────────────────────┘
               │
┌──────────────────────────────────────┐
│  DEPOSIT  ALIGNMENT  LAYER 15         │──── S4
└──────────────────────────────────────┘
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┌──────────────────────────────────────┐
│  PLACE EACH SPACER 17 IN DITCH        │──── S5
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        │     END     │
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Application for United States Patent
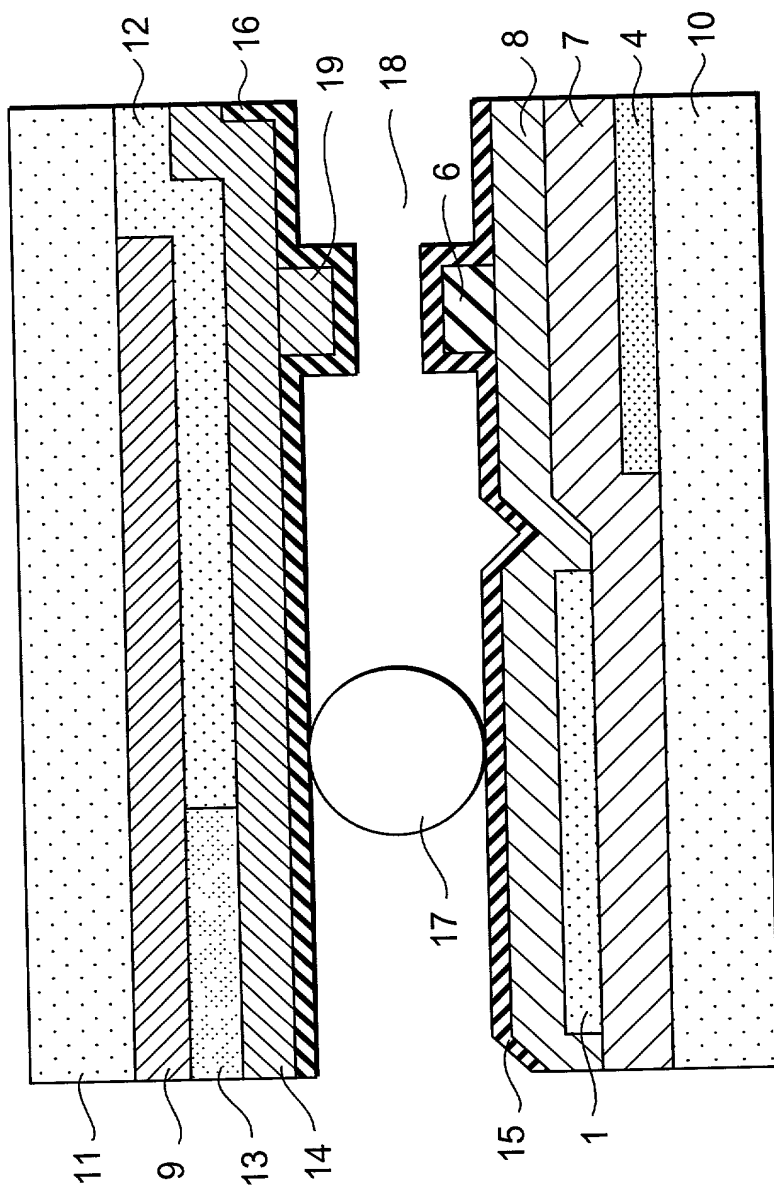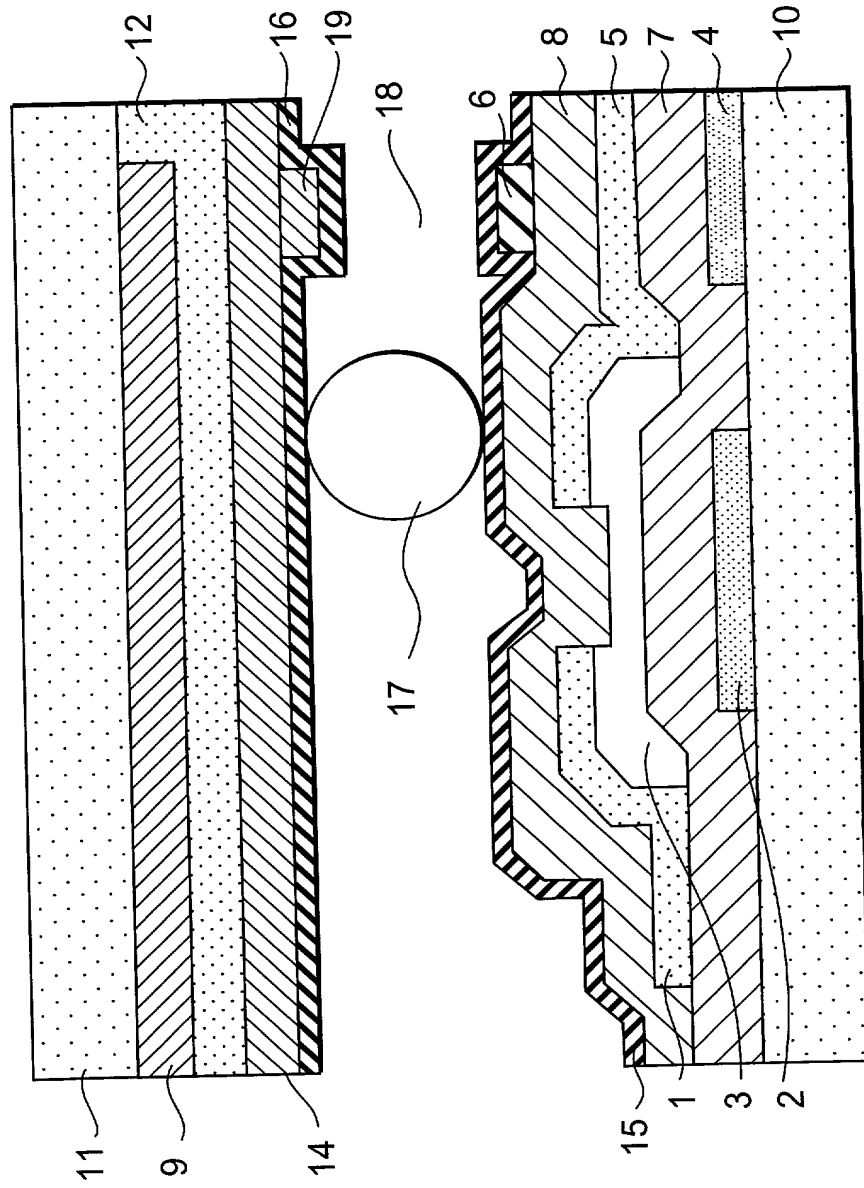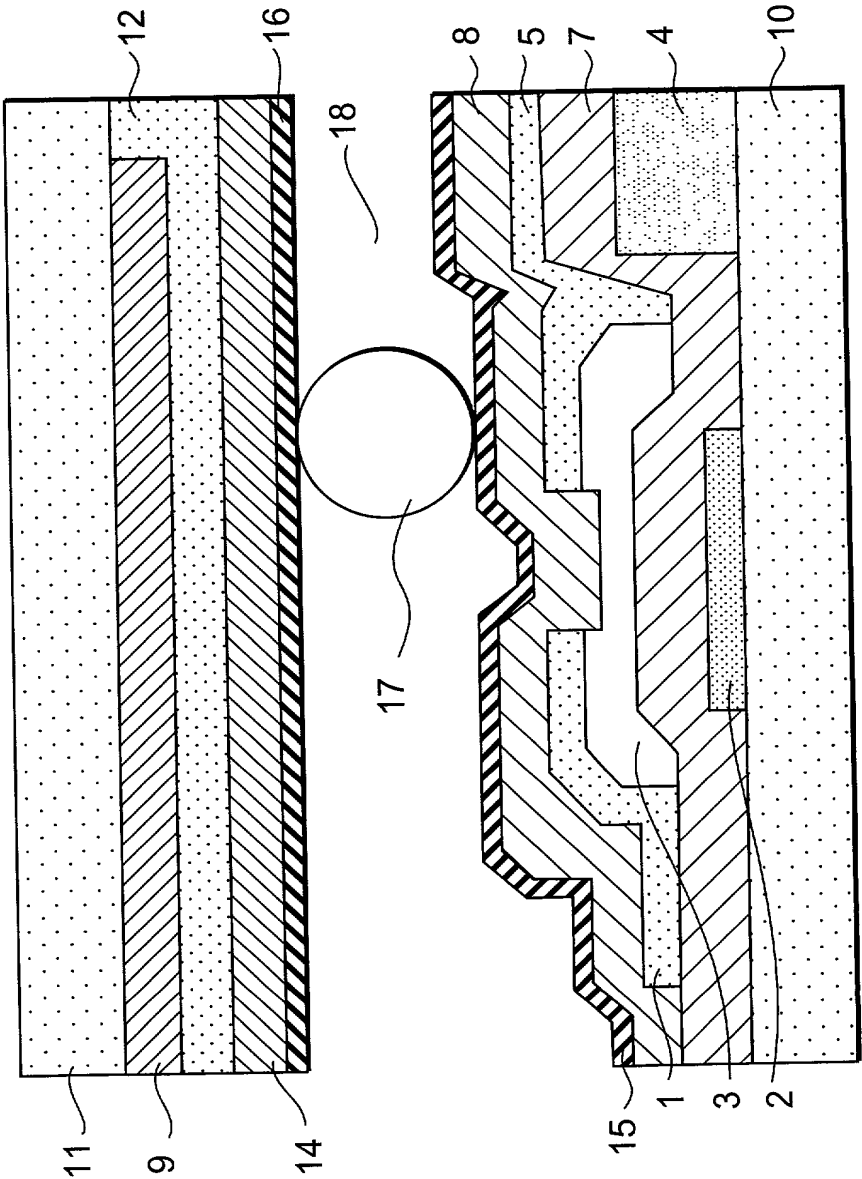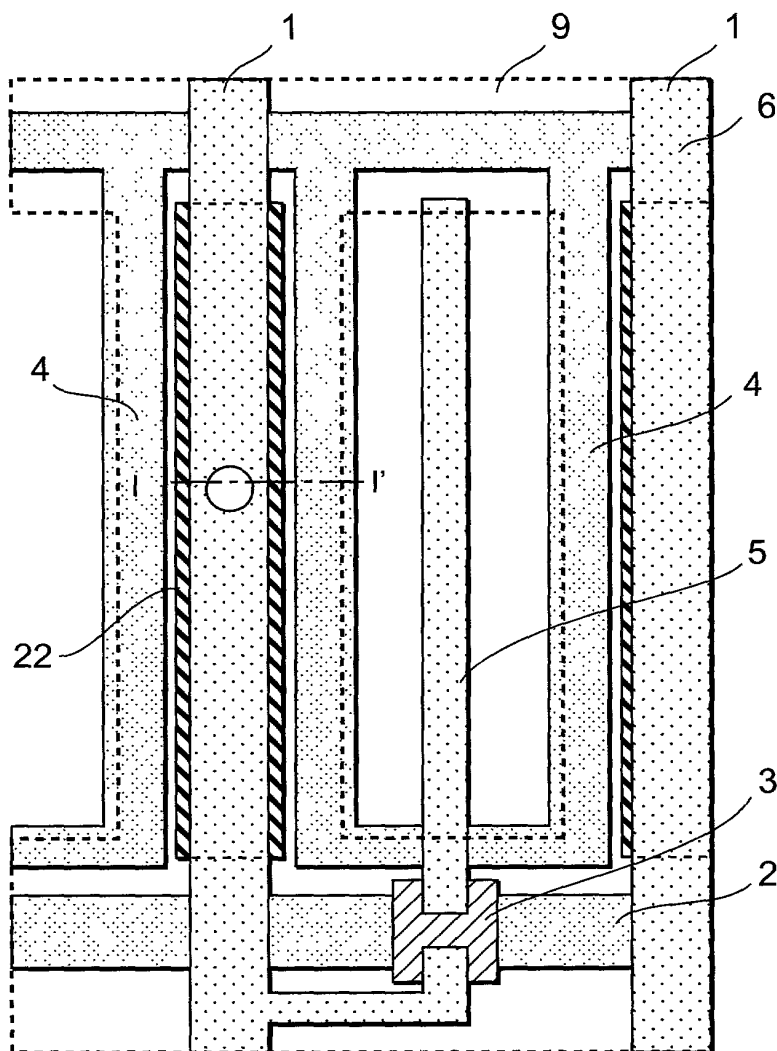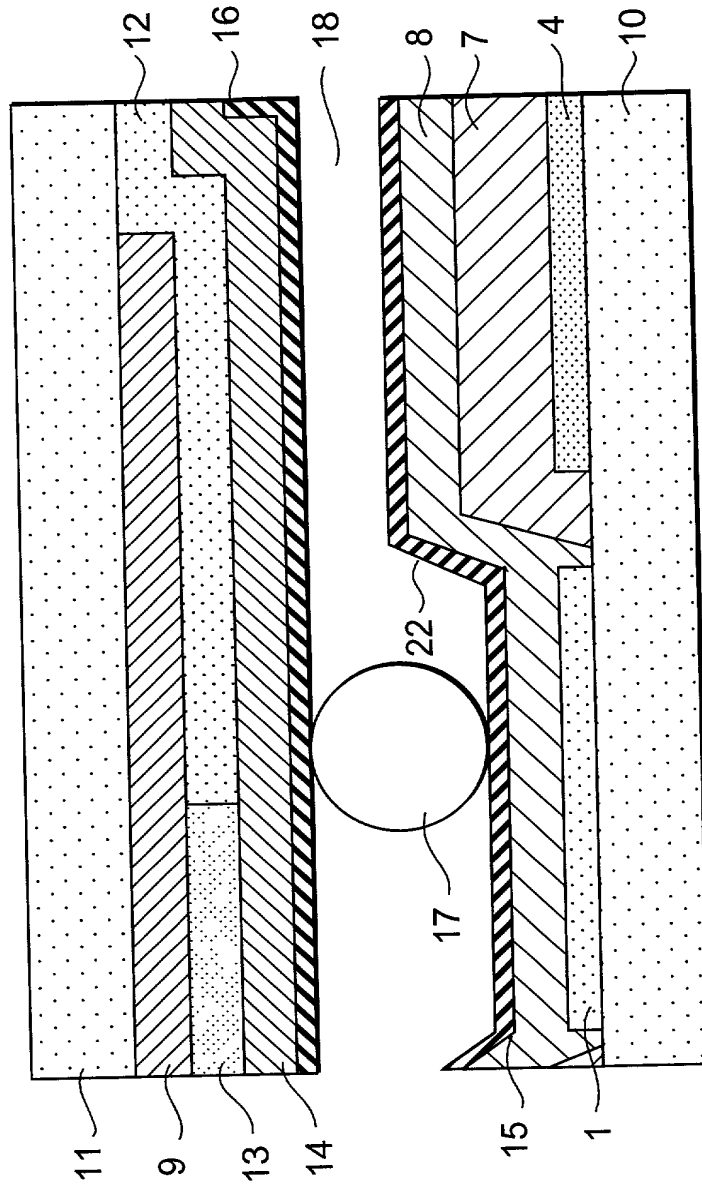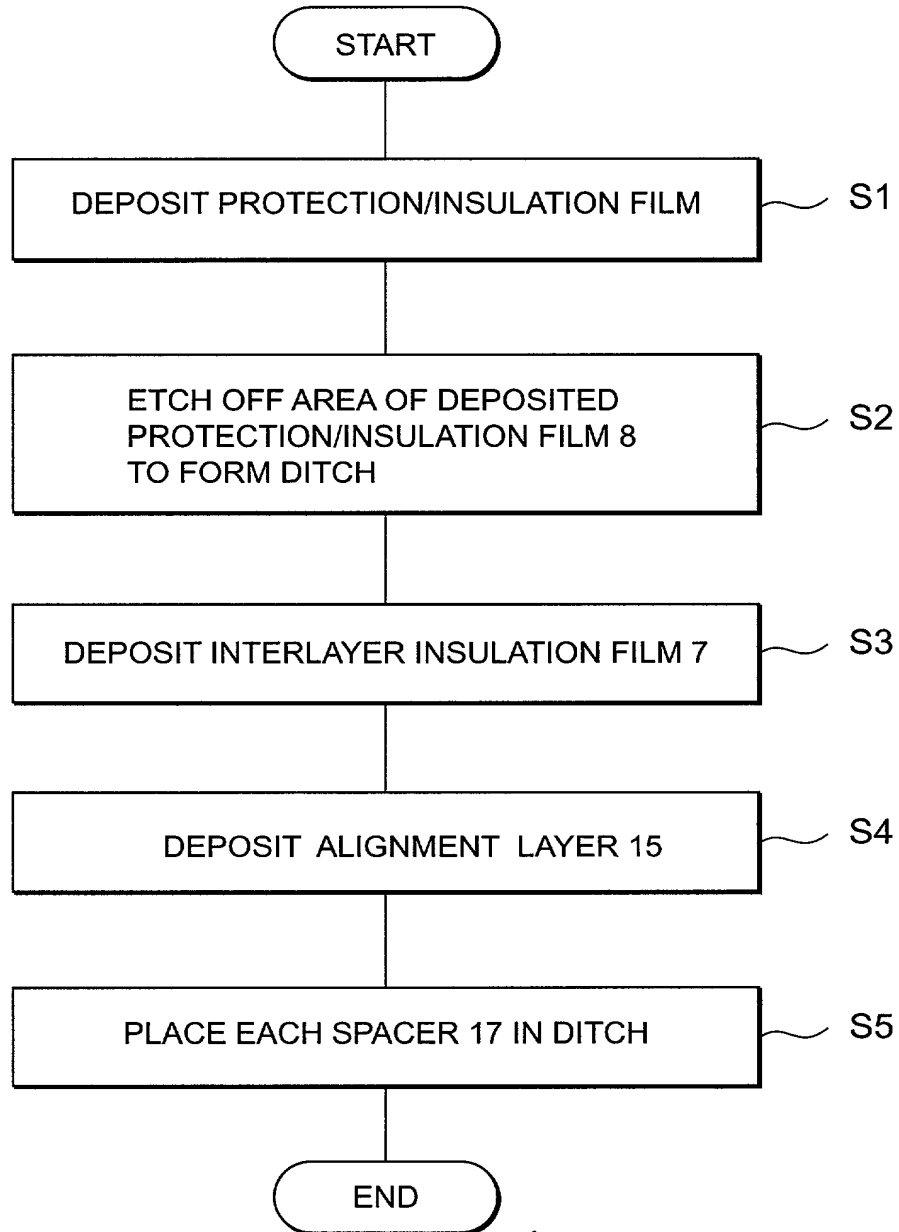
DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF

the specification of which:

(check one)

☑ is attached hereto

☐ was filed on _____, as
Application Serial No. _____
and was amended on _____.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56*

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

			priority claimed	
64317/1999	Japan	11/3/1999	X	
(Number)	(Country)	(Day/Month/Year Filed)	yes	no
(Number)	(Country)	(Day/Month/Year Filed)	yes	no
(Number)	(Country)	(Day/Month/Year Filed)	yes	no

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)

Power of Attorney: As a named inventor, I hereby appoint Sean M. McGinn, Reg. 34,386, and Frederick W. Gibb, III, Reg. No. 37,629 as attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. All correspondence should be directed to **McGinn & Gibb, P.C., 1701 Clarendon Boulevard, Suite 100, Arlington, Virginia 22209.** Telephone calls should be directed to McGinn & Gibb, P.C. at **(703) 294-6699.**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful

false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole
or First Inventor____SHOICHI KUROHA_____

Inventor's Signature ___*Shoichi Kuroha*_____ Date____3/3/2000_____

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Joint Inventor, If Any_____

Inventor's Signature _____ Date _____

Residence _____

Citizenship _____

Post Office Address _____

Full Name of Third

Joint Inventor, If Any _____

Inventor's Signature _____ Date _____

Residence _____

Citizenship _____

Post Office Address _____

Full Name of Fourth
Joint Inventor, If Any _____

Inventor's Signature _____ Date _____

Residence _____

Citizenship_____

Post Office Address _____

(An additional sheet(s) is/are attached hereto if the present invention includes more than four inventors.)

*Title 37, Code of Federal Regulations, § 1.56:

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith toward the Patent and Trademark Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and (1) it establishes , by itself or in combination with other information, a prima facie case of unpatentability; or (2) it refutes, or is inconsistent with, a position the applicant takes in: (i) opposing an argument of unpatentability relied on by the Office, or (ii) asserting an argument of patentability.